Shear Performance of Pre-damaged PVA-Aggregate Mixed ECC Beam

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1. INTRODUCTION

Polyvinyl Alcohol Engineered Cementitious Composite (PVA-ECC) is a unique example of Strain Hardening Cementitious Composites (SHCCs) which shows superior tensile ductility. In this material, considerable tensile property is realized through the formation of fine, multiple cracks due to the existence of PVA fiber. Shear performance of this material at crack, however, has not been investigated cautiously. Recently, it was found that coarse aggregate, when added to the ECC, improves the material behavior in terms of cracking and load-carrying resistance for shear, particularly when subjected to a complex stress field. Also, authors have performed bi-directional beam tests on this material. For the further investigation into shear performance of these materials under stress rotation field from structural point of view, three types of bi-directional stress beam tests were conducted in both PVA-ECC and PVA-course aggregate mixed ECC. In this test series, damage level in pre-crack phase was set much higher than previous tests to reproduce a severe shear condition under stress rotation.

2. SHEAR BEAM TEST

Three series of tests were performed in PVA-ECC and PVA-aggregate mixed material. The maximum size of aggregate was 9.5mm, and mixed 15% by volume, which values were referred from previous researches. Figure 1 and Table 1 show the details of tests. Beam tests with bi-directional stress were conducted by introducing pre-crack. The objective of the preloading state was to investigate into the shear performance under rotating stress field that may cause severe crack slippage. In this test, pre-crack was firstly introduced in short span (see Fig.1(a)) which was set as 200mm. After introducing pre-crack, the shear span was expanded to 550mm (see Fig.1(b)), then beams were reloaded to the failure. To observe shear failure effectively, stirrups were set at only one side of the specimen, and the failure was lead to occur on the other side. To determine the load level for introduction of pre-crack in case “precracked-350”, preliminary experiment on the same specimen was performed, and the load level was set as 350kN. Also, in case “precracked-failure”, precrack was introduced to almost failure, where increase of load during the test became nearly flat in load-displacement curve. In “non-precracked” case, span was kept in second loading (Fig.2(b)) condition through whole loading process.

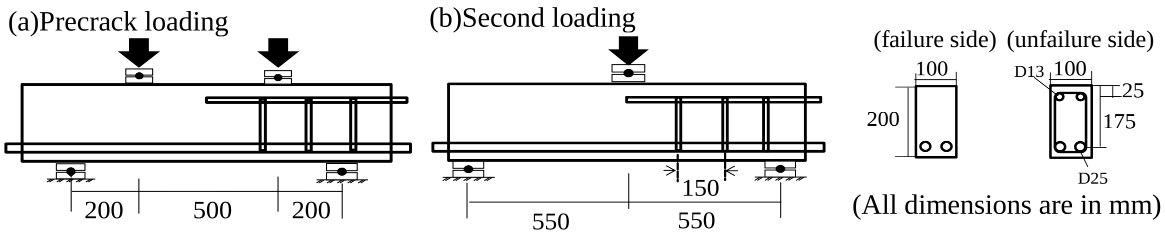

Figure 1 Specimen details and loading conditions

Table 1 Detail of specimens

Test series	Load level of pre-crack (kN)	Material	Beam size (mm)	a/d	Longitudinal reinforcement (%)	Reinforcement	Stirrup
non-precracked	-	Normal ECC	100×200×1200	3.14	4.9	2D25 USD685	3D13 USD390
		ECC+Aggregate					
precracked-350	350kN	Normal ECC					
	350kN	ECC+Aggregate					
precracked-failure	458kN	Normal ECC					
	479kN	ECC+Aggregate					

3. TEST RESULTS

The results of three types of tests are shown in Figure 2. In ECC+Aggregate material, load-displacement data of “non-precracked” case was missed from a certain point due to the error of data logger. To fill up this loss, the data which obtained from image data analysis that was performed simultaneously was used and drawn in the graph.

When there are no precracks, Normal ECC attained comparable higher shear capacity than ECC+Aggregate. It is known that the existence of aggregate weaken the tensile property of ECC because aggregate obstruct fiber bridging on the crack surface. Tensile behavior is more dominant than shear behavior in pure shear failure under non precracked condition in beam test, so that this result suits for the knowledge that has been obtained from previous researches.

Keywords: PVA-ECC, course aggregate, shear, stress rotation, precrack
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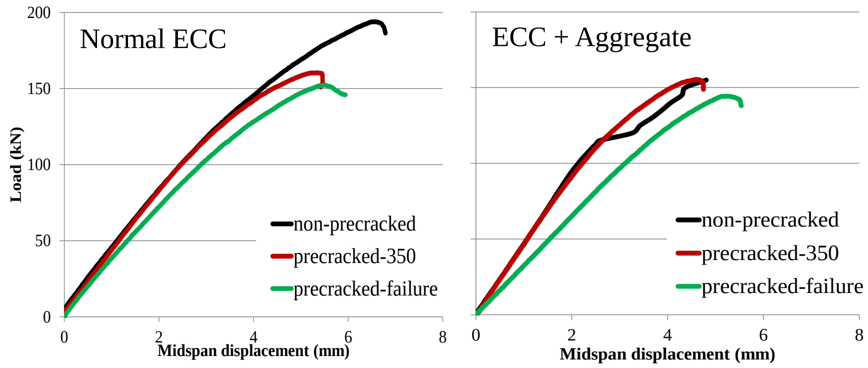

Figure 2 Results of shear beam tests

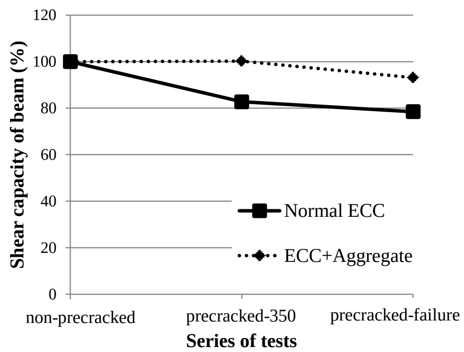

Figure 3 Comparison of shear capacity of beam

On the other hand, when there are precracks, shear capacity in both materials have no significant difference, and when these capacities are compared to non-precracked case in each material, ECC+Aggregate attained exceedingly better performance in terms of small drop of shear capacity (see Fig.3). The reason for this result is effective contribution of coarse aggregate. Under severe stress rotation field, more considerable shear movement would occur compared to under non precracked condition where pure shear failure occur. In such a severe shear condition, the contribution of resistive shear performance of coarse aggregate can be performed. Figure 4 shows clear images of these phenomena. In Normal ECC, crack surface becomes flat due to absence of aggregate, and PVA fiber can only resist for shear stress. However, PVA fibers are not able to endure shear movement owing to its soft material property. On the other hand, in ECC+Aggergate, shear stress is able to be carried by aggregate, and it increase shear resistance on crack surface. When stress rotation would occur on crack surface (i.e. severe shear stress would be occurred), this contribution of aggregate could be effective significantly.

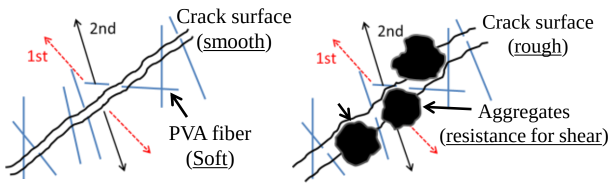

Figure 4 Images of material behavior on crack

Also, Figure 5 shows crack patterns of all materials after failure. Observed failure crack is signified in the figures, and it can be found that failure cracks occurred along precrack in precracked cases. Also, number of cracks can be observed more in Normal ECC (except ECC precracked-350), and this result suits for previous researches which showed that aggregate lower crack distribution in ECC material. Clear effect of coarse aggregate under stress rotation field, however, could not be observed from investigation into crack patterns.

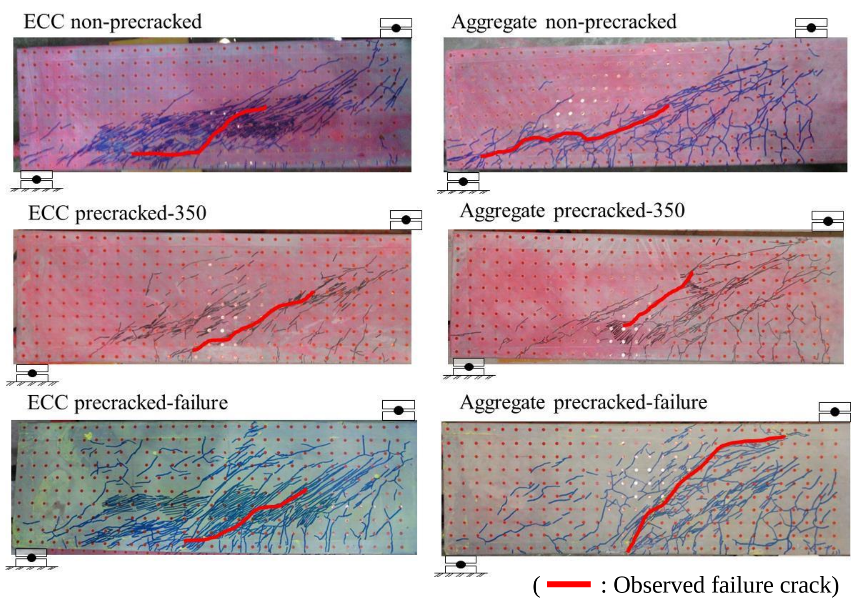

Figure 5 Crack patterns of all materials

4. CONCLUSION

Shear capacity of ECC beam was lowered due to the existence of coarse aggregate under non-precracked condition. Under pre-cracked condition, however, dropping rate of shear capacity of Aggergate mixed-ECC was less compared with non-precracked condition owing to shear resistance performance of coarse aggregate at crack surface that implies the robust material under stress rotation field.

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